The fuse-selection checklist: a quick update

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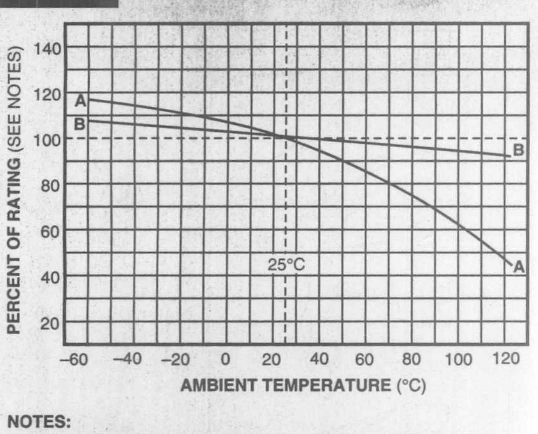
To be complete, a fuse-selection checklist now must include the I^2t parameter. A quick review of this checklist makes it easy to select a fuse for a specific application.

sing fuses in electronic circuits for overcurrent protection is an established practice. Likewise, a fuse selection checklist, in one orm or another, has existed or many years. You now need to update that list to nclude the I^2t parameter of a fuse. The I^2t rating helps you void "nuisance" openings—openings that occur under a ircuit's normal operating conditions.

A complete fuse-selection checklist now includes: ampere ating, voltage rating, temperature derating, overload openng times, interrupting rating, I^2t rating, fuse size and type of nounting, resistance, agency approvals.

Depending on your application, the dominant fuse paraneter and order of importance vary. These parameters are based on one or more of the following application requirenents: the ability to carry the normal operating current, the ability to open the circuit at the desired fault-current level, and general safety issues. A quick review of these parameters and a more detailed analysis of the I^2t parameter helps ease fuse selection.

FIGURE 1



NOTES:
AMBIENT TEMPERATURE EFFECTS ARE IN ADDITION TO THE NORMAL DERATING.
CURVE A: TRADITIONAL SLO-BLO FUSES.
CURVE B: VERY FAST-ACTING, AND SPIRAL-WOUND SLO-BLO FUSES.

These temperature-derating curves show the suggested derating of two fuse types (A and B).

Ampere rating. Select the ampere rating for the fuse so that the fuse can carry the normal operating-current conditions of the application. The recommended operating current for the fuse is 75% of the nominal rating. The derating of 25% compensates for the differences between the documented UL-rating test procedure and the typical application.

Voltage rating. A fuse's voltage rating is a safety issue. This rating must equal or exceed the application circuit's operating voltage. Operating a fuse above its voltage rating risks a potential explosion of the fuse or a fire. Fuses are current-sensitive, and you can successfully operate a fuse at any voltage below its rated voltage.

Temperature derating. Temperature derating is necessary so that the fuse can carry the normal operating current of the application. Fuses are thermal-responding devices, and derating is necessary for ambient temperatures above 25°C. UL-rating tests are performed at 25°C, and this derating is in addition to the 25% ampere derating. **Figure 1**, a chart of ambient temperature vs percent of rating, shows the suggested derating.

Overload opening times. You should select overload opening times based on the requirement to open the circuit at the desired fault-current level. You can determine the opening time at various current overloads using the time-current curve for a fuse. The overload-opening-time requirement of the application represents the "protection" you expect from the fuse.

Interrupting rating. The interrupting rating is a safety issue. It is the maximum fault current that the fuse can safely open at rated voltage.

I^2t rating. A fuse's I^2t rating, which is measured in units of amperes-squared seconds (A^2sec), is the amount of energy required to melt the fuse element. An I^2t analysis of an application helps to avoid a "nuisance" opening of a fuse. A nuisance opening is a fuse opening that occurs under normal

FUSE-SELECTION CHECKLIST

operating conditions for the circuit. Such an opening generally results from misapplication of the fuse.

An I^2t analysis is most useful in situations in which a start-up pulse or a series of pulses is normal. To select the proper fuse, you need to first determine the I^2t energy in the pulse. Then, you can calculate the fuse's I^2t rating using the number of cycles desired and the I^2t ratio chart. The chart plots the number of pulses the fuse can withstand as a function of the ratio of the pulse I^2t to fuse I^2t rating.

A short example shows you how to determine the required I^2t rating of a fuse for a specific application. For this example, the selected fuse must withstand 100,000 cycles of the pulse waveform (**Figure 2**). You can calculate the I^2t energy in the pulse using the following equation:

You can also approximate the energy in the pulse using

$$I^2t = \int i^2(t)dt.$$

established charts for several common waveforms (**Figure 3**).

The formula to calculate I^2t for waveform E in **Figure 3** is

$$I^2t = {}^1\!/_5(i_p)^2t = {}^1\!/_5 \times 8^2 \times 0.004 = 0.0512\ A^2sec.$$

The ratio chart in **Figure 4** indicates that, to withstand 100,000 cycles, the ratio of the pulse's I^2t to the fuse's I^2t is approximately 0.22. Thus,

$$(\text{pulse } I^2t/\text{fuse } I^2t) = 0.22,$$

and

$$\text{fuse } I^2t = 0.0512/0.22 = 0.2327\ A^2sec.$$

In other words, the minimum fuse I^2t rating necessary to withstand 100,000 cycles of this example's pulse is 0.2327 A^2sec. You base your actual fuse selection on a review of the manufacturer's I^2t rating data.

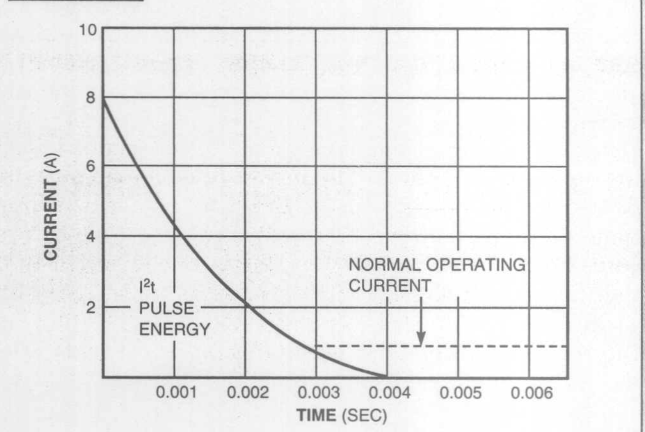
The last step in this analysis is to make sure the selected fuse meets the other requirements of the application. That is, you need to determine whether the fuse can handle the normal steady-state operating current with proper derating for the ambient temperature and if the fuse provides the necessary overcurrent protection.

Fuse size and type of mounting. Each application determines the fuse size and type of mounting you need, and there are a variety of products from which to choose. Many fuse holders are available, but the current trend is to use surface-mount fuses.

Resistance. The resistance of a fuse usually increases as the nominal ampere rating decreases. You need to be aware that the voltage drop across the fuse can be appreciable, especially for fuses with a low-ampere rating.

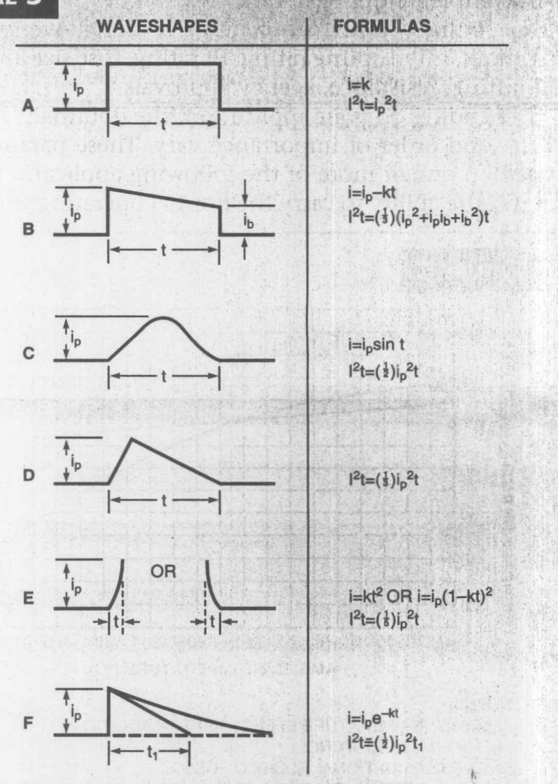
Agency approvals. One widely accepted industry source for the performance requirements of fuses is UL (Underwriters Laboratories) Standard 198G for supplemental fuses. A new joint UL/CSA (Canadian Standards Association) standard is being developed, and portions of it have been issued. The new standard, UL248 or CSA248, includes a part that replaces UL198G. These standards include the necessary agency-approval requirements for safety. The most common approvals required in North America are UL and CSA. The fuse applications for export to or manufacture in Europe and Asia generally call for some agency approval to the Interna-

FIGURE 2



An I^2t analysis involves determining the energy to which the fuse is subjected, such as the energy in 100,000 cycles of this pulse waveform.

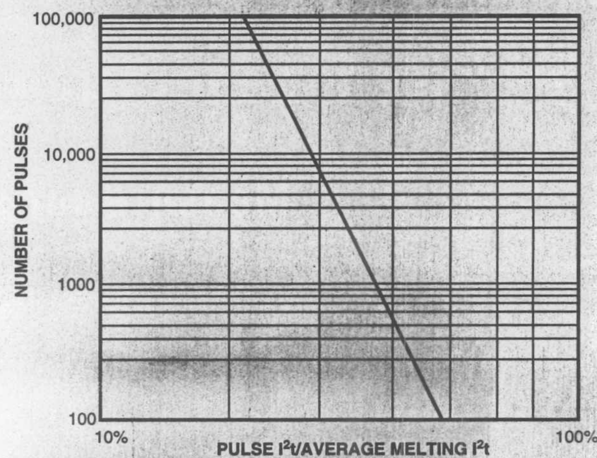
FIGURE 3



Depending on the waveshape of your application, you can use the corresponding formulas to determine the I^2t energy in the pulse.

FUSE-SELECTION CHECKLIST

FIGURE 4



To withstand 100,000 pulses, the ratio of the pulse's I^2t to the fuse's I^2t is approximately 0.22.

tional Electrotechnical Commission (IEC) specifications.

UL listing, CSA certification, and approval to an IEC specification all require the fuse to meet the performance requirements detailed in the specifications. The opening-time-at-overload requirements for UL/CSA are different enough from the IEC specification that it is physically impossible for a fuse to meet both requirements. UL/CSA each offer a level of approval in which the manufacturer is allowed to specify some of the performance requirements. These approvals are identified as the "Recognition under the Component Program" for UL and "Component Acceptance" for CSA. These forms of approval allow manufacturers to design and test a fuse to the IEC requirements and then submit those same performance requirements to UL and CSA. You can call the Littelfuse Technical Assistance line at (800) 999-9445 with questions. EDN

Author's biography

Len Lundy is a product marketing manager for Littelfuse Inc, De Plaines, IL. He has been with the company for 19 years and ha helped develop a line of surface-mount fuses. Lundy received BSEE and an MBA from the Illinois Institute of Technolog (Chicago).

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